**Focused Ion Beam Sensitization for Selective Triggering of Electrochemical Dissolution and Deposition on Semiconductor Surfaces**

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The work demonstrates new pathways to achieve selective chemical or electrochemical nanogrowth or -structuring of materials on locally sensitized single crystal semiconductor surfaces. Sensitization is carried out by focused ion beam (FIB) implant / damage writing. This high resolution local writing technique allows for feature definition in the 10-200 nm range. At these locally activated surface locations a subsequent chemical or electrochemical reaction is triggered selectively, leading to the nanosize material or functionality.

The principle for achieving selectivity of the electrochemical reaction is outlinedin Fig. 1. A semiconductor / electrolyteinterface, when electrochemically biased, shows a similar electrical characteristic as a diode with a current passing state when forward biased and a blocking state when reverse biased. In the blocking state a specific “barrier breakdown”potential U(Bd) exists that can be ascribed toSchottky barrier breakdown of the junction. At an applied voltage U > U(Bd), electrochemical reactions are not hampered any longer by insufficient availability of charge carriers and thus can proceed at significant rates. The value of U(Bd) is strongly affected by surface defects, i.e., breakdownoccurs for much lower applied bias voltages than for the intact surface, opening a window for selective processing between the two threshold voltages.

Thus by FIB damage writing followed by an electrochemical dissolution or deposition reaction at an appropriate voltage, the electrochemical process that remains laterally confined within the damage pattern, can be used for a direct "maskless" patterning.

Examples are the selective formation of light emitting porous silicon (Fig. 2) or the selective deposition of metals (Fig. 3) on FIB damage patterns (1, 2). The examples and the underlying mechanism will be discussed in detail.

References

1 P. Schmuki, L. E. Erickson, and D. J. Lockwood, Phys. Rev. Lett., 80, 4060 (1998).
2 P. Schmuki, L. E. Erickson, Phys. Rev. Lett., 80, 4060 (2000).

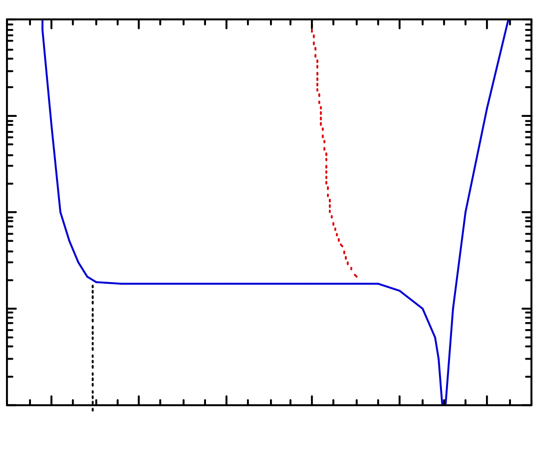

Fig. 1 Schematic current - voltage curve of an intact and defective p-type semiconductor surface polarized in anelectrolyte.

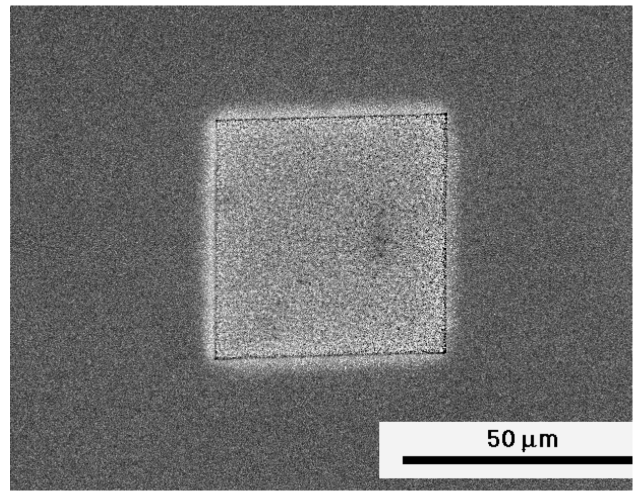


Fig 2. Selective formation of porous Si on n-Si (100): SEM image of a FIB implanted $Si^{++}$ square (200 keV; dose = $10^{14}$ $cm^{-2}$) after polarization from oc to 3000 mV (Ag/AgCl) in 20% HF (leading porosification of the implanted region).

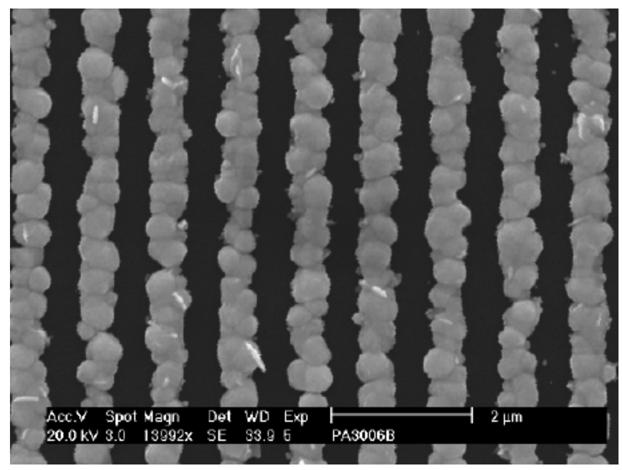


Fig 3. Selective Au deposition on p-Si (100): SEM image of FIB implanted $Si^{++}$ lines (200 keV; dose=$10^{14}$ $cm^{-2}$ ) after polarization from -900 mV to -5000 mV (Ag/AgCl) in a 1 M KCN + 0.01M $KAu(CN)_2$ electrolyte (leading to Au deposition only on the implanted regions).